

Homework #5

Released: 11/24/2014 (Mon) - Due: 12/3/2014 (Wed), in class

The homework will NOT be graded, but we will check for MISSING ANSWERS and CHEATING. Note that a cheated homework will get 80% of the lowest score in the class. You can give the answers either in English or Korean.

1. [Air pollution] One day, you analyzed the air at Gwanak campus over an hour. The hourly-averaged concentrations of SO₂, CO, and NO₂ were measured to be 50, 125, and 250 μg/m³, respectively. The Korean air quality standards for hourly-averaged concentrations of SO₂, CO, and NO₂ are 0.15, 25, and 0.10 ppm, respectively. Does any of the three pollutants exceed the Korean air quality standards? The atmospheric pressure and temperature at Gwanak campus during the analysis were 1 atm and 15°C, respectively.

Answer)

$$\text{Unit conversion: } \frac{\mu g_i}{m_{air}^3} = ppm_i \times MW_i \times \frac{P}{RT} \quad \rightarrow \quad ppm_i = \frac{\mu g_i}{m_{air}^3} \times \frac{1}{MW_i} \times \frac{RT}{P}$$

Molecular weights of SO₂, CO, and NO₂: 64.1, 28, and 46 g/mole, respectively

$$\text{for SO}_2: 50 \mu g/m^3 \times \frac{1}{64.1 \text{ g/mole}} \times \frac{8.21 \times 10^{-5} \text{ m}^3 - \text{atm/K} - \text{mole} \cdot 288 \text{ K}}{1 \text{ atm}} = 0.018 \text{ ppm}$$

$$\text{for CO: } 125 \mu g/m^3 \times \frac{1}{28 \text{ g/mole}} \times \frac{8.21 \times 10^{-5} \text{ m}^3 - \text{atm/K} - \text{mole} \cdot 288 \text{ K}}{1 \text{ atm}} = 0.11 \text{ ppm}$$

$$\text{for NO}_2: 250 \mu g/m^3 \times \frac{1}{46 \text{ g/mole}} \times \frac{8.21 \times 10^{-5} \text{ m}^3 - \text{atm/K} - \text{mole} \cdot 288 \text{ K}}{1 \text{ atm}} = 0.13 \text{ ppm}$$

∴ The NO₂ concentration exceeds the Korean air quality standard.

2. [Air pollution] Uncontrolled burning of plant materials such as fallen leaves and rice straws may significantly affect the local air quality. List the major air pollutants that

may be generated by uncontrolled burning of natural plant materials.

Answer)

Carbon monoxide, particulates, and some hydrocarbons can be generated by uncontrolled burning of plant materials.

3. [Air pollution] List processes to remove particulate matter in the air emitted from a point source. Briefly explain the removal mechanism.

Answer)

Cyclone: The polluted air is injected into the device at high speed. The air swirls inside the device, creating a centrifugal force which makes the particulates separated from the air, stick to the inner wall, and eventually collected at the bottom. The cleaned air exits to the top of the device.

Filter: The polluted air is treated by the size exclusion mechanism of the filter, letting the clean air to pass through the filter but not allowing so for the particulates. When the particulates are accumulated on the filter such that significant pressure drop occurs, the filter is mechanically shaken to let the accumulated particulates to fall down and collected in a hopper located at the bottom.

Liquid scrubbing: The polluted air is contacted with liquid droplets. Liquid droplets are attached to the particulates, resulting in the growth of the particle size. Thus, the particulates are made more suitable for removal by simple gravity-based removal devices such as cyclone.

Electrostatic precipitation: The polluted air is passed through the device where a high electric voltage is applied. This creates an electron flow from the wire, which is in negative charge, to the plate, which is in positive charge. The electrons are attached to the particulates passing through the device so that the particulates get negatively charged. The negatively-charged particulates move towards the plate by the electric force and eventually collected on the plate.

4. [Solid waste management] Select one day of the homework preparation period (11/24 to 12/2) to record all the solid wastes you produce. List the wastes you produced and classify them into non-recyclables, recyclables, and food waste. How much solid waste (in grams) are you producing in a day? You do not have to weigh the solid waste, but just make a guess.

Answer)

The answer is up to individuals.

1. [Solid waste management] (International students: select either A or B; Korean students: select A)

A. Look up the regulation standards for sanitary landfill in your own country. Describe the guideline for the landfill liner to prevent the landfill leachate to escape from the landfill.

* Guide for Korean students: 인터넷 홈페이지 <http://www.law.go.kr>로 들어가면 모든 국내 법-시행령-시행규칙의 검색이 가능. 폐기물관리법 시행규칙을 검색하여 선택한 후, [별표 9] 확인.

Answer)

* *The following is for the Korean standard. Each country may have different standards.*

Korean standard (해당 별표 2. 나. 2)항에 관리형 매립시설 = 위생매립지 (sanitary landfill)의 침출수 차단시설 기준이 수록):

i) when synthetic polymer such as high-density polyethylene (HDPE) is used: At least one layer of the synthetic polymer with ≥ 2.0 mm thickness with an additional clay liner having a hydraulic conductivity of $\leq 10^{-7}$ cm/s with a thickness of ≥ 50 cm.

ii) when clay is used as a single liner material: a clay liner having a hydraulic conductivity of $\leq 10^{-7}$ cm/s with a thickness of ≥ 1 m.

B. Find the most recent value of daily per capita production of solid wastes for your own country. Compare the value with those for others provided in the lecture note. Briefly

discuss the reason why your country produces greater/smaller amount of solid wastes compared to other countries.

Answer)

The solid waste production depends on various factors - the Gross national production (GNP), the governmental policy, public attitude towards solid waste generation and reduction, cultural difference and lifestyle, climate, etc.

Find the reasonable clue from the various potential factors.